OIPE IAP97 JAN 30 2008 PATENT & TRADEMARK OFFICE

S/N: 10/799,685 1/21/2008 DOCKET NO.: 136009

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: **Takashi ITO, et al.**

Serial No.: **10/799,685** Art Unit: **4123**

Filed: **March 15, 2004** Examiner: **Mr. Michael T. Piery**

For: **Optical Device Molding Die Designing Method**

DECLARATION: TRANSLATION ACCURACY

I am the translator of the paragraph 【0027】 of the publication document, Japanese Unexamined Patent Publication No. 2002-096344, and am fluent in both the Japanese and English languages. I hereby declare upon penalty of perjury that above-mentioned translation of the publication document incorporated into the Response is accurate and believed to be true. This statement is made with the knowledge that willful false statements and the like so made are punishable by fine and imprisonment, or both under Section 1001 of title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Date: **January 25, 2008**

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-096344

(43)Date of publication of application : 02.04.2002

(51)Int.Cl.
B29C 43/36
B29C 45/26
C03B 11/00
G02B 3/00
G02B 3/04
// B29L 11:00

(21)Application number : 2000-290455 (71)Applicant : SONY CORP

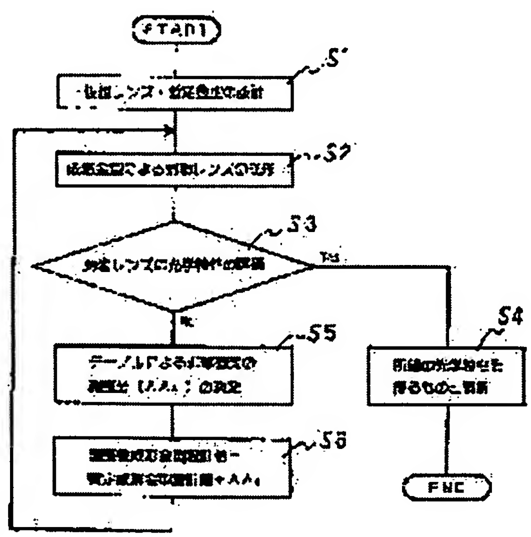
(22)Date of filing : 25.09.2000 (72)Inventor : KAWAKITA SATOSHI

(54) METHOD FOR DESIGNING MOLD FOR MOLDING LENS, AND MOLDED LENS

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method for designing a mold for molding a lens, and the lens accurately having desired optical characteristics without being affected by the shrinkage of a material, the change quantity of a refractive index or the like being the indefinite elements of the lens.

SOLUTION: A tentative mold 2 is formed on the basis of a predetermined shape design value and a tentative lens 1 is molded by the tentative mold, and the optical characteristics of the molded tentative lens are measured to be compared with desired optical characteristics to detect the shift quantity of the spherical aberration value thereof. The shift quantity of an aspheric aberration value shifted from the desired optical characteristics as a result of detection is collated with a table T preliminarily calculating the relation between the fine change quantity Ai of higher order among the aspheric surface constant Ai of a formula prescribing an aspheric surface and the variation quantity of the aspheric surface aberration value, and the fine change quantity of higher order among the corresponding aspheric surface constant is determined as adjusting quantity and the adjusting quantity is added to the aspheric surface constant of the formula for prescribing the aspheric



surface of the tentative mold to design a final mold as a new shape design value.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

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[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] While performing provisional shaping metal mold (henceforth "provisional shaping metal mold") creation based on a predetermined geometric design value and fabricating a provisional lens (henceforth a "provisional lens") with this provisional shaping metal mold While measuring the optical property of the fabricated provisional lens and detecting the amount of gaps of the spherical-aberration value as compared with a desired optical property The relation between the minute variation of a high order term and the amount of fluctuation of a spherical-aberration value is tested by comparison on the table for which it asked beforehand among the aspheric surface constants of the formula which specifies the aspheric surface for the amount of gaps of the aspheric surface aberration value [optical property / desired] shifted as a result of detection. The design approach of the shaping metal mold of the lens characterized by determining the minute variation of a high order term as an amount of adjustments among corresponding aspheric surface constants, adding this amount of adjustments to the aspheric surface constant of the formula which specifies the aspheric surface of the above-mentioned provisional shaping metal mold, and designing shaping metal mold final as a new geometric design value.
[Claim 2] While creating provisional shaping metal mold (henceforth "provisional shaping metal mold") based on a predetermined geometric design value and fabricating a provisional lens (henceforth a "provisional lens") with this provisional shaping metal mold While measuring the optical property of the fabricated provisional lens and detecting the amount of gaps of the spherical-aberration value as compared with a desired optical property The minute variation of a high order term, the amount of fluctuation of a spherical-aberration value, and relation are tested by comparison on the table for which it asked beforehand among the aspheric surface constants of the formula which specifies the aspheric surface for the amount of gaps of the aspheric surface aberration value [optical property / desired] shifted as a result of detection. The lens characterized by fabricating with the final shaping metal mold which determined the minute variation of a high order term as an amount of adjustments among corresponding aspheric surface constants, added this amount of adjustments to the aspheric surface constant of the formula which specifies the aspheric surface of the above-mentioned provisional shaping metal mold, and was designed as a new geometric design value.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the design approach of the shaping metal mold of a new lens, and the lens which this fabricated. It is related with the technique of aiming at improvement in the optical property of the fabricated lens in detail.
[0002]
[Description of the Prior Art] If it is in the optical disk drive equipment which uses optical disks, such as CD (compact disk) and DVD (digital video disc), as a record medium, an objective lens is used for the optical pickup, and, as for this objective lens, mold goods, such as glass and plastics, are used.
[0003] Based on an optical design, it succeeds in that geometric design so that this objective lens may obtain a desired optical property beforehand (this geometric design value is hereafter called "ideal geometric design value".), and shaping metal mold is designed with this ideal geometric design value and the same geometric design value of concavo-convex reverse.
[0004] However, in order to contract mold goods after shaping, a desired configuration (configuration of an ideal geometric design value) cannot be maintained, but the fabricated objective lens may differ from the thing of a request of the optical property.
[0005] Then, in order to obtain the objective lens which carried out the configuration of an ideal geometric design value, there is the design approach of the shaping metal mold shown in JP,5-96572,A.
[0006] a lens provisional at the shaping metal mold created provisionally according to the design approach of the shaping metal mold shown in this JP,5-96572,A -- fabricating -- the above -- when it asks for a configuration regression curve from the difference of the geometry value of provisional shaping metal mold, and the configuration measured value of a lens and a shaping metal mold design feeds this back, it is going to create new shaping metal mold.
[0007] Thereby, the lens approximated to the configuration of an ideal geometric design value can be fabricated.
[0008]
[Problem(s) to be Solved by the Invention] However, the present condition is being unable to obtain a desired optical property (spherical aberration) by minute difference of the refractive index of an ingredient, the thickness of a lens, etc., if the transmitted wave side aberration which is optical interference measurement estimates even if it is the lens fabricated in this way.
[0009] In connection with the densification of the recording density of DVD etc., conventionally, the width of face of the permitted tolerance is becoming narrow, and we are especially anxious about the yield of a shaping lens getting worse in recent years.
[0010] Then, this invention makes it a technical problem to offer the lens which has a desired optical property with a sufficient precision, without being influenced by the ingredient contraction which is the indefinite element of a lens, change of a refractive index, etc. about the design approach of the shaping metal mold of the lens fabricated, and the lens fabricated by this.
[0011]

[Means for Solving the Problem] In order that the design approach of the shaping metal mold of this invention lens may solve the above-mentioned technical problem While creating provisional shaping metal mold based on a predetermined geometric design value and fabricating a provisional lens with this provisional shaping metal mold While measuring the optical property of the fabricated provisional lens and detecting the amount of gaps of the spherical-aberration value as compared with a desired optical property The relation between the minute variation of a high order term and the amount of fluctuation of a spherical-aberration value is tested by comparison on the table for which it asked beforehand among the aspheric surface constants of the formula which specifies the aspheric surface for the amount of gaps of the aspheric surface aberration value [optical property / desired] shifted as a result of detection. The minute variation of a high order term is determined as an amount of adjustments among corresponding aspheric surface constants, this amount of adjustments is added to the aspheric surface constant of the formula which specifies the aspheric surface of the above-mentioned provisional shaping metal mold, and shaping metal mold final as a new geometric design value is designed.
[0012] Moreover, while this invention lens creates provisional shaping metal mold based on a predetermined geometric design value and fabricating a provisional lens with this provisional shaping metal mold While measuring the optical property of the fabricated provisional lens and detecting the amount of gaps of the spherical-aberration value as compared with a desired optical property The relation between the minute variation of a high order term and the amount of fluctuation of a spherical-aberration value is tested by comparison on the table for which it asked beforehand among the aspheric surface constants of the formula which specifies the aspheric surface for the amount of gaps of the aspheric surface aberration value [optical property / desired] shifted as a result of detection. The minute variation of a high order term is determined as an amount of adjustments among corresponding aspheric surface constants, and it fabricates with the final shaping metal mold which added this amount of adjustments to the aspheric surface constant of the formula which specifies the aspheric surface of the above-mentioned provisional shaping metal mold, and was designed as a new geometric design value.
[0013] Therefore, if it is in the design approach of the shaping metal mold of this invention lens, and the lens which this fabricated Since adjustment of the spherical aberration which there is no need that the evaluation about the fabricated lens analyzes finely ingredient contraction, change of a refractive index, etc. which are a thing about an optical property and are the indefinite element of a lens, and includes these is possible, Since the lens equipped with the optical property for which it asks can be fabricated and the amount of adjustments is moreover made into the minute variation of a high order term among the aspheric surface constants of the formula which specifies the aspheric surface, By choosing the high order term suitably, highly precise adjustment can be performed and the lens approximated by the desired optical property can be fabricated easily.
[0014]
[Embodiment of the Invention] Below, the design approach of the shaping metal mold of this invention lens and the gestalt of operation of the lens which this fabricated are explained with reference to an accompanying drawing.
[0015] Drawing 1 shows typically the shaping metal mold 2 used for shaping of the objective lens 1 for CD.
[0016] The shaping metal mold 2 consists of the heaters 5 and 5 arranged so that the bottom shaping metal mold 3 created by the desired configuration, the bottom shaping metal mold 4 created by the desired configuration, and these might be inserted from right and left.
[0017] A cavity 6 is formed between the bottom shaping metal mold 3 and the bottom shaping metal mold 4, a molding material 7 is located in this cavity 6 considering fuselages 8 and 8 as a guide, and a molding material 7 is heated and pressed at the above-mentioned heaters 5 and 5.
[0018] Thereby, the objective lens 1 with which the configuration of the bottom shaping metal mold 3 and the bottom shaping metal mold 4 was imprinted is fabricated.
[0019] And in order to obtain the objective lens 1 which has a desired optical property, the design approach of shaping metal mold is explained according to the flow chart Fig. of drawing 2 .
[0020] - Step 1 (S1)

The objective lens 1 and the provisional shaping metal mold 2 of the imagination which has the lens side of a predetermined configuration are designed. The formula which specifies the lens side of the objective lens 1 of this imagination is shown in "a-one number." That of "a-one number" is a formula which specifies the aspheric surface, and assumes the lens side of an ideal by the "-one number (1)" formula mostly by the optical simulation of an optical property.
[0021] Moreover, the shaping side of an ideal is similarly assumed mostly by the "-one number (2)" type about the provisional shaping metal mold 2.
[0022]
[Equation 1]

$$Z_L = X^2/R_L/[1+\{1-(1+K_L)(X/R_L)^2\}^{1/2}]+\Sigma A_{Li}X^i \cdots\cdots\cdots (1)$$

$$Z_K = X^2/R_K/[1+\{1-(1+K_K)(X/R_K)^2\}^{1/2}]+\Sigma A_{Ki}X^i \cdots\cdots\cdots (2)$$

なお、

Z_L:レンズの光軸方向値

Z_K:金型設計の光軸方向値

X:光軸に垂直な方向値

R_L:レンズの曲率半径

R_K:金型の曲率半径

K_L:レンズの円錐定数

K_K:金型の円錐定数

A_{Li}:レンズの非球面定数

A_{Ki}:金型の非球面定数

[0023] - Step 2 (S2)
A lens is fabricated with shaping metal mold. When step 2 (S2) flows from the above-mentioned step 1 (S1), this shaping metal mold turns into the above-mentioned provisional shaping metal mold 2. Since it is not necessarily a thing with the optical property of a final request, let this lens be the provisional objective lens 1. Moreover, in flowing from step 6 (S6) mentioned later, this shaping metal mold turns into shaping metal mold after adjustment.
[0024] - Step 3 (S3)
The optical property is measured and evaluated about the fabricated objective lens 1. An interference fringe and the 3rd spherical-aberration value are acquired for example, by transmitted wave side measurement, and the existence of gap with a desired optical property is judged to be evaluation of an optical property. When gap is between the optical properties for which progress to step 4 (S4) and it asks when there is no gap between the optical properties for which it asks as a result of evaluation, it progresses to step 5 (S5).
[0025] In the case of the above-mentioned provisional objective lens 1, gap has usually arisen in the optical property. As a result of performing transmitted wave side measurement about this provisional objective lens 1, suppose that the 3rd spherical-aberration value (+0.020lambdarms) shown in the interference fringe shown in drawing 3 (a) and drawing 3 (b) was acquired. When this interference fringe is observed, it turns out that the vertical part is swinging [each stripes]. "+0.020lambdarms" In the ideal objective lens which can obtain the optical property for which it asks, the above-mentioned interference fringe is a straight line, and the 3rd spherical-aberration value is "0", and if it is in this provisional objective lens 1, the spherical-aberration value will have shifted.
[0026] - Step 4 (S4)
The fabricated objective lens 1 has a desired optical property, and can judge the shaping metal mold 2 which fabricated this as shaping metal mold 2 which can fabricate the objective lens 1 with a desired

deviation

optical property. In addition, when the provisional objective lens 1 has a desired optical property, the provisional objective lens 1 to apply is not provisional any longer, and is just an objective lens 1. Moreover, it can be judged that the above-mentioned provisional shaping metal mold 2 which fabricated this is not provisional, either, and is just the shaping metal mold 2.
[0027] - Step 5 (S5)
It checks on the table T which set up beforehand gap from the optical property of a request of the provisional objective lens 1 by the optical simulation, and an adjusted part of the shaping metal mold 2 is determined. Table T shows the correspondence relation between the variation (deltaA4) when changing "the aspheric surface constant Ai" minutely about the above "a-one number (2)", and the amount of fluctuation of a spherical-aberration value. This table T is shown in drawing 4 as a table.
[0028] For example, if "-0.5E-05" change of the 4th term (A4) of the "-one number (2)" type of the bottom provisional shaping metal mold 3 is carried out When a spherical-aberration value (3rd order) carries out "+0.005lambdarms" fluctuation and "+0.5E-05" change of the 4th term (A4) of a "-one number (2)" type is carried out, drawing 4 shows that a spherical-aberration value (3rd order) carries out "-0.005lambdarms" fluctuation.
[0029] Similarly, if "-1.0E-05" change of the 4th term (A4) of the "-one number (2)" type of the bottom provisional shaping metal mold 4 is carried out When a spherical-aberration value (3rd order) carries out "-0.008lambdarms" fluctuation and "+1.0E-05" change of the 4th term (A4) of the "-one number (2)" type of the bottom provisional shaping metal mold 4 is carried out, drawing 4 shows that a spherical-aberration value (3rd order) carries out "-0.008lambdarms" fluctuation.
[0030] And an adjusted part for the spherical-aberration value of the optical property of the provisional objective lens 1 to be "+0.020lambdarms", and cancel this by the above-mentioned step 3 (S3), is chosen from drawing 4 . What is necessary is just to specifically discover a changed part of each deltaA4 from which the changed sum total of addition and subtraction by a changed part and/or the bottom provisional shaping metal mold 4 by the bottom provisional shaping metal mold 3 is set to "-0.020lambdarms", in order to cancel "+0.020lambdarms." Consequently, if a changed part "-0.011lambdarms" by the bottom provisional shaping metal mold 3 and a changed part "-0.008lambdarms" by the bottom provisional shaping metal mold 4 are totaled, it will be set to "-0.019lambdarms", and it turns out that a part for the above-mentioned gap is mostly cancelable. Therefore, in this example, it determines as deltaA4=-1.0E-05 as an adjusted part of the upper provisional shaping metal mold 3 as an adjusted part of deltaA4=+1.0E-05 and the lower provisional shaping metal mold 4, and progresses to step 6 (S6).
[0031] - Add an adjusted part of deltaA4 determined by step 6 (S6) step 5 (S5) above "a-one number (2)", and design the bottom shaping metal mold 3 and the bottom shaping metal mold 4 again. Therefore, the formula of the shaping side of the shaping metal mold 3 and 4 after adjustment becomes like "a-two number." In addition, only the 4th term of the above "a-one number" is taken out and described in "a-two number."
[0032]
[Equation 2]

$$\text{調整後の上側金型設計}\ A_4 = \text{上金型の}\ A_{K4} + 1.0\times10^{-5} \cdots\cdots\cdots (3)$$

$$\text{調整後の下側金型設計}\ A_4 = \text{下金型の}\ A_{K4} - 1.0\times10^{-5} \cdots\cdots\cdots (4)$$

[0033] Thus, shaping of return and an objective lens 1 is performed to step 2 (S2) by the designed shaping metal mold 2.
[0034] The deer was carried out, and as a result of performing the optical property of the objective lens 1 fabricated with the shaping metal mold 2 after this adjustment at step 3 (S3), an interference fringe and the 3rd spherical-aberration value (-0.001lambdarms) as shown in drawing 5 (b) were acquired. The shaping metal mold 2 after the adjustment which the objective lens 1 concerned has the optical property and configuration for which it asks by progressing to step 4 (S4), therefore fabricated this by this can also be judged as shaping metal mold 2 which can fabricate the objective lens 1 with a desired optical property.
[0035] In addition, although the optical simulation of the spherical aberration by minute variation

deltaA4 of only the term of "A4" of the "-one number (2)" type of a vertical lens side was shown in Table T as an example of a typical objective lens as mentioned above, by not restricting to this and adjusting high order spherical aberration further, still minuter adjustment can be performed and an optical property can be raised further. In this case, it is necessary to investigate the correspondence relation between the 3rd high order spherical-aberration more than value and the combination (sigmadeltaAiXi) of a high order term beforehand as a table.

[0036] Moreover, although each was adjusted about the vertical lens side of an objective lens if it was in the gestalt of the above-mentioned implementation, this invention may be made to adjust about not only this but one of lens sides (either [i.e.,] bottom shaping metal mold or bottom shaping metal mold). Thus, if one of shaping metal mold is adjusted, when the objective lens with which spherical aberration (3rd order) differed in the objective lens of the same kind needs to fabricate two or more kinds, for example, in order to obtain volume efficiency, one configuration of shaping metal mold is fixed, and the objective lens which has a desired optical property can be fabricated also by changing the aspheric surface constant Ai very small about the shaping metal mold of another side.

[0037] In addition, although this invention was applied to the objective lens of an optical pickup in the gestalt of the above-mentioned implementation, this invention is applicable not only to this but the general lens fabricated like plastics and glass.

[0038] Moreover, in the gestalt of the above-mentioned implementation, although the shaping approach by the press was explained, this invention is applicable to the shaping approach, for example, injection molding etc., of using not only this but shaping metal mold.

[0039] In addition, it passes over no the configurations and structures of each part which were shown in the above-mentioned gestalt of operation to what showed a mere example of the somatization which hits carrying out this invention, and the technical range of this invention is not restrictively interpreted by these.

[0040]

[Effect of the Invention] So that clearly from the place indicated above the design approach of the shaping metal mold of this invention lens While creating provisional shaping metal mold based on a predetermined geometric design value and fabricating a provisional lens with this provisional shaping metal mold While measuring the optical property of the fabricated provisional lens and detecting the amount of gaps of the spherical-aberration value as compared with a desired optical property The relation between the minute variation of a high order term and the amount of fluctuation of a spherical-aberration value is tested by comparison on the table for which it asked beforehand among the aspheric surface constants of the formula which specifies the aspheric surface for the amount of gaps of the aspheric surface aberration value [optical property / desired] shifted as a result of detection. It is characterized by determining the minute variation of a high order term as an amount of adjustments among corresponding aspheric surface constants, adding this amount of adjustments to the aspheric surface constant of the formula which specifies the aspheric surface of the above-mentioned provisional shaping metal mold, and designing shaping metal mold final as a new geometric design value.

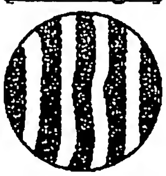
[0041] Moreover, while this invention lens creates provisional shaping metal mold based on a predetermined geometric design value and fabricating a provisional lens with this provisional shaping metal mold While measuring the optical property of the fabricated provisional lens and detecting the amount of gaps of the spherical-aberration value as compared with a desired optical property The relation between the minute variation of a high order term and the amount of fluctuation of a spherical-aberration value is tested by comparison on the table for which it asked beforehand among the aspheric surface constants of the formula which specifies the aspheric surface for the amount of gaps of the aspheric surface aberration value [optical property / desired] shifted as a result of detection. It is characterized by fabricating with the final shaping metal mold which determined the minute variation of a high order term as an amount of adjustments among corresponding aspheric surface constants, added this amount of adjustments to the aspheric surface constant of the formula which specifies the aspheric surface of the above-mentioned provisional shaping metal mold, and was designed as a new geometric design value.

[0042] Therefore, if it is in the design approach of the shaping metal mold of this invention lens, and the lens which this fabricated Since adjustment of the spherical aberration which there is no need that the evaluation about the fabricated lens analyzes finely ingredient contraction, change of a refractive index, etc. which are a thing about an optical property and are the indefinite element of a lens, and includes these is possible, Since the lens equipped with the optical property for which it asks can be fabricated and the amount of adjustments is moreover made into the minute variation of a high order term among the aspheric surface constants of the formula which specifies the aspheric surface, By choosing the high order term, highly precise adjustment can be performed and the lens approximated by the desired optical property can be fabricated easily.

[Translation done.]

DRAWINGS

[Drawing 3]



(a)

球面収差(3次)値
+0.020 λrms

(b)

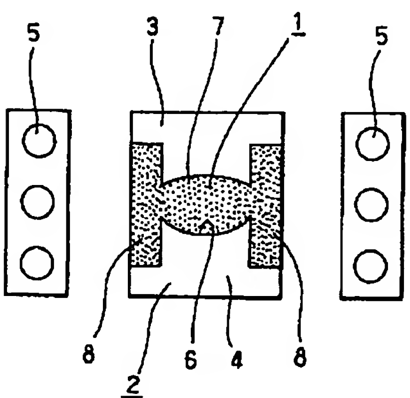
[Drawing 4]

T…テーブル

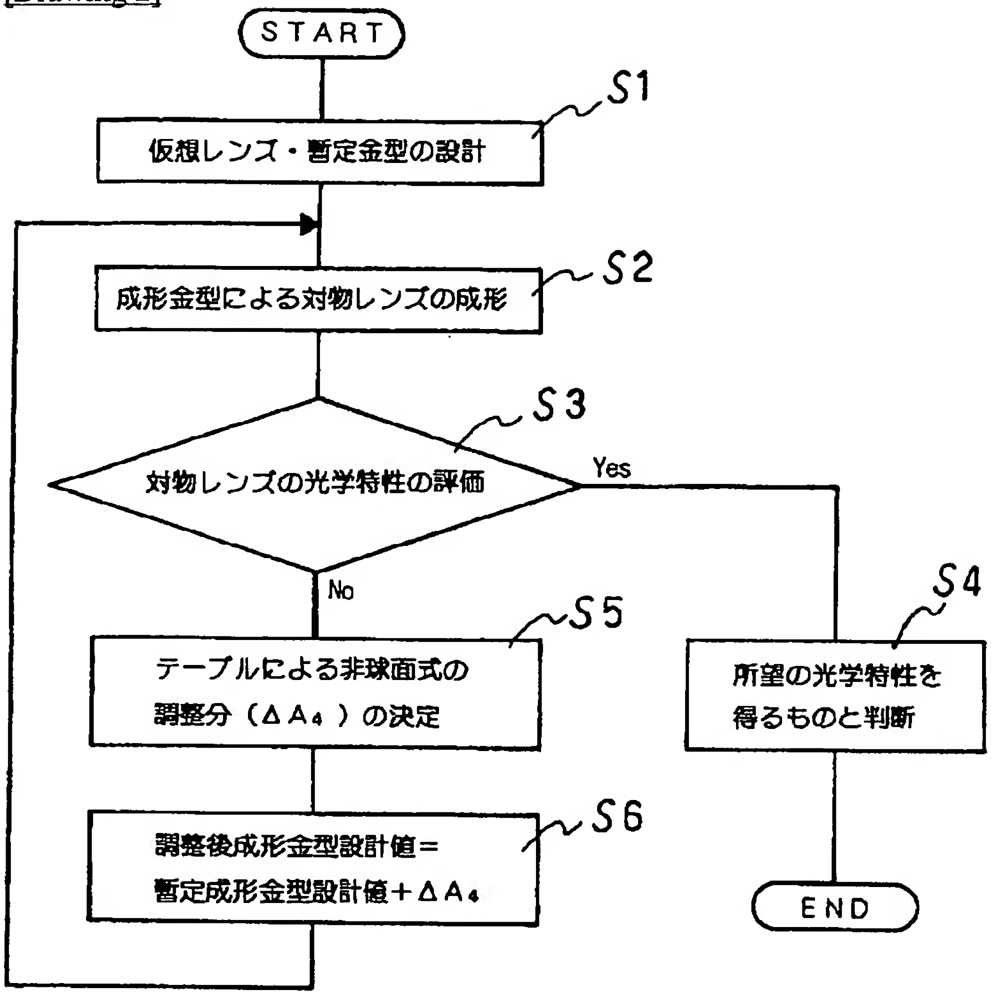
上型側の ΔA4	球面収差(3次)の増減 (λrms)	下型側の ΔA4	球面収差(3次)の増減 (λrms)
-2.0E-05	0.022	-4.0E-05	-0.032
-1.5E-05	0.16	-3.0E-05	-0.024
-1.0E-05	0.011	-2.0E-05	-0.016
-0.5E-05	0.005	-1.0E-05	-0.008
0	0	0	0
0.5E-05	-0.005	1.0E-05	0.008
1.0E-05	-0.011	2.0E-05	0.016
1.5E-05	-0.016	3.0E-05	0.024
2.0E-05	-0.022	4.0E-05	0.032

[Drawing 1]

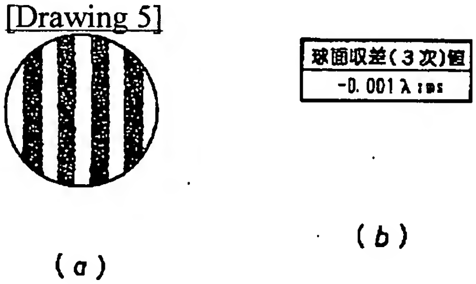
1…対物レンズ
2…成形金型



[Drawing 2]



[Drawing 5]



[Translation done.]